



US011191645B2

(12) **United States Patent**
Champagne et al.

(10) **Patent No.:** **US 11,191,645 B2**

(45) **Date of Patent:** **Dec. 7, 2021**

(54) **SMALL BONE TAPERED COMPRESSION SCREW**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/122,325**

(22) Filed: **Sep. 5, 2018**

(65) **Prior Publication Data**

US 2019/0070009 A1 Mar. 7, 2019

Related U.S. Application Data

(60) Provisional application No. 62/554,133, filed on Sep. 5, 2017.

(51) **Int. Cl.**
A61F 2/30 (2006.01)
A61F 2/42 (2006.01)
A61B 17/72 (2006.01)
A61B 17/86 (2006.01)

(52) **U.S. Cl.**
CPC **A61F 2/30771** (2013.01); **A61B 17/7291** (2013.01); **A61B 17/863** (2013.01); **A61F 2/4225** (2013.01); **A61F 2/4241** (2013.01); **A61F 2002/30622** (2013.01); **A61F 2002/30858** (2013.01); **A61F 2002/4228** (2013.01); **A61F 2002/4243** (2013.01)

(58) **Field of Classification Search**

CPC A61F 2/42; A61F 2002/4228; A61F 2002/4243; A61F 2002/4251; A61F 2/4241; A61F 2002/4233; A61F 2002/4238; A61B 17/8645; A61B 17/8605; A61B 17/863; A61B 17/8004; A61B 17/8014; A61B 2017/8655; A61B 17/84; A61B 17/86

See application file for complete search history.

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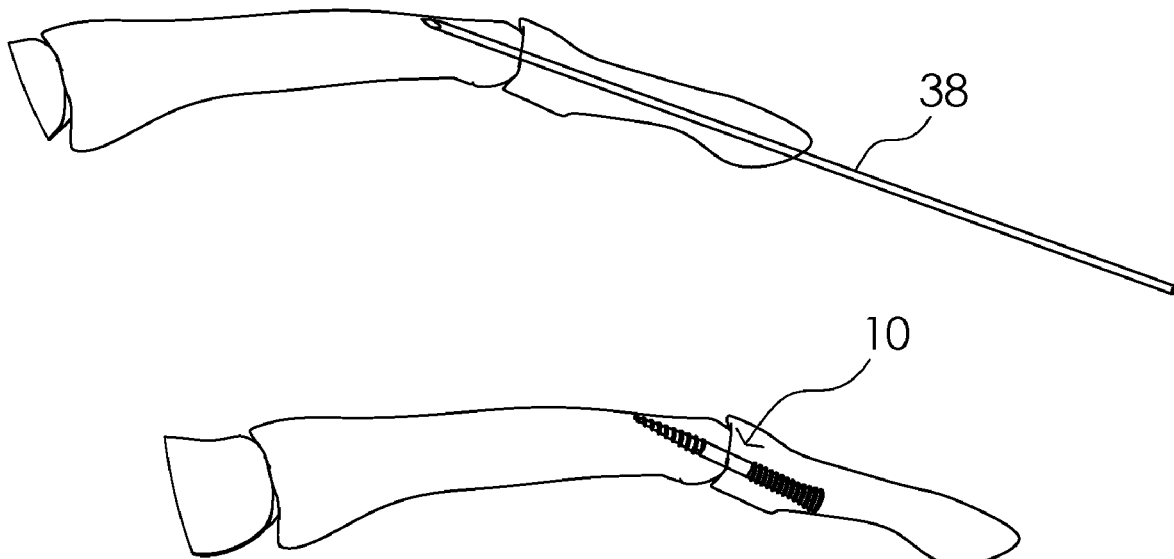
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(57) **ABSTRACT**

The present invention relates to a device and system for surgical fixation of small bones, small bone fragments, and osteotomies and more particularly to compression screw having an elongated and spiked tapered threaded leading portion which is joined to a section that is free from threads and a threaded trailing portion and more sharply tapered head which has threads that continue from the threads of the leading portion.

14 Claims, 3 Drawing Sheets



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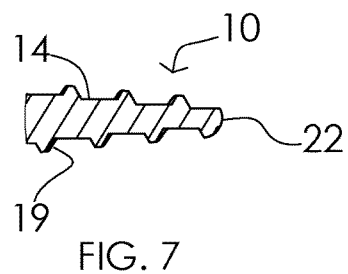
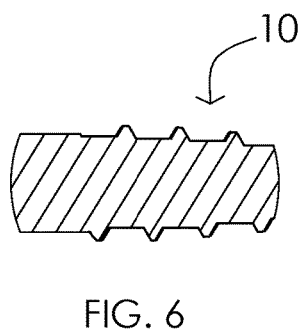
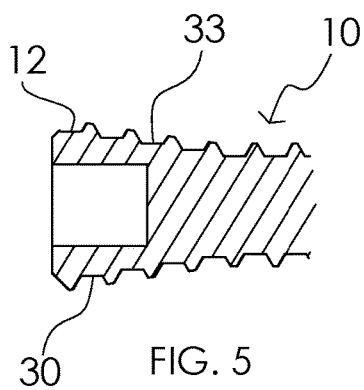
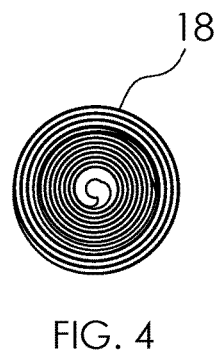
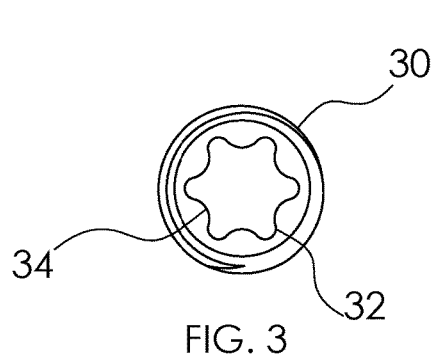
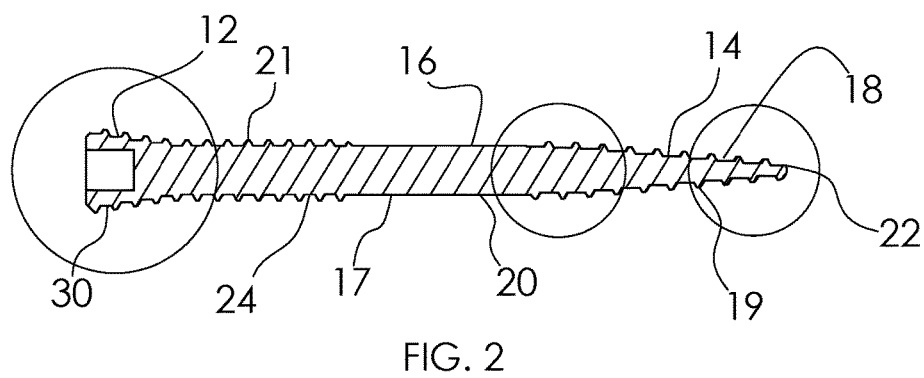
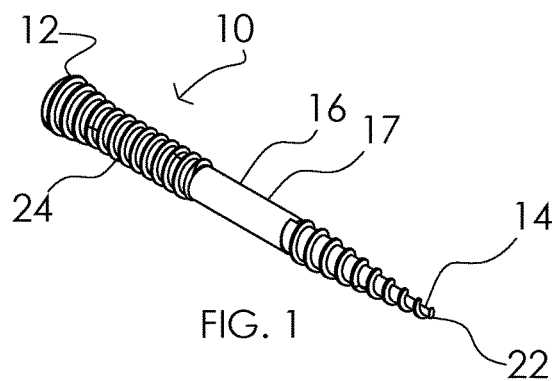
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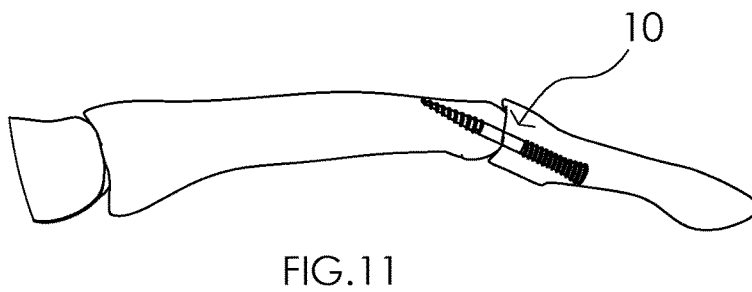
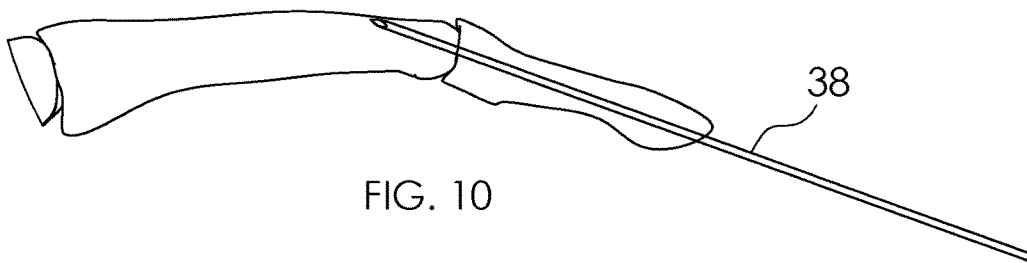
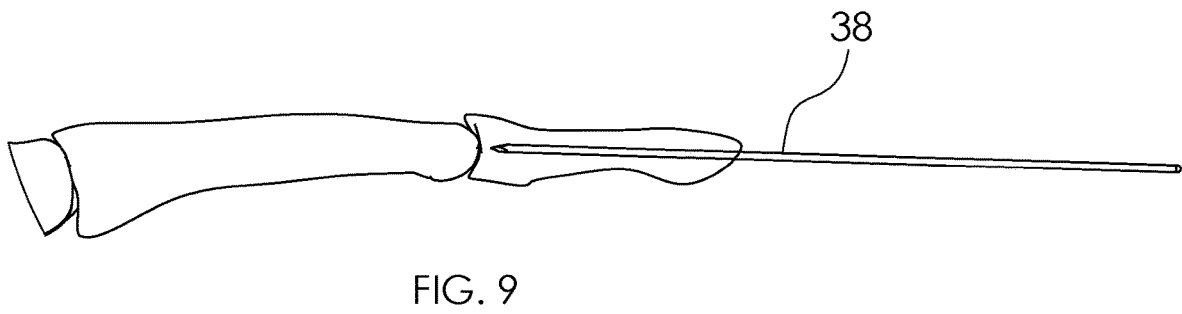
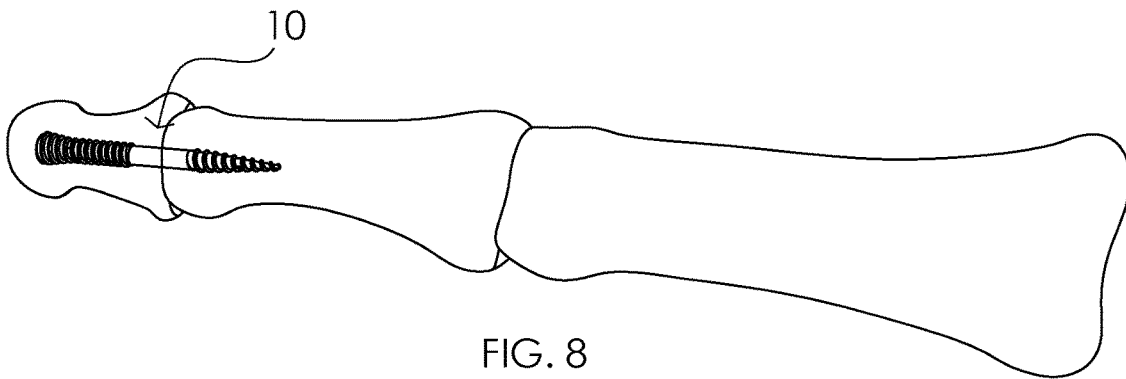
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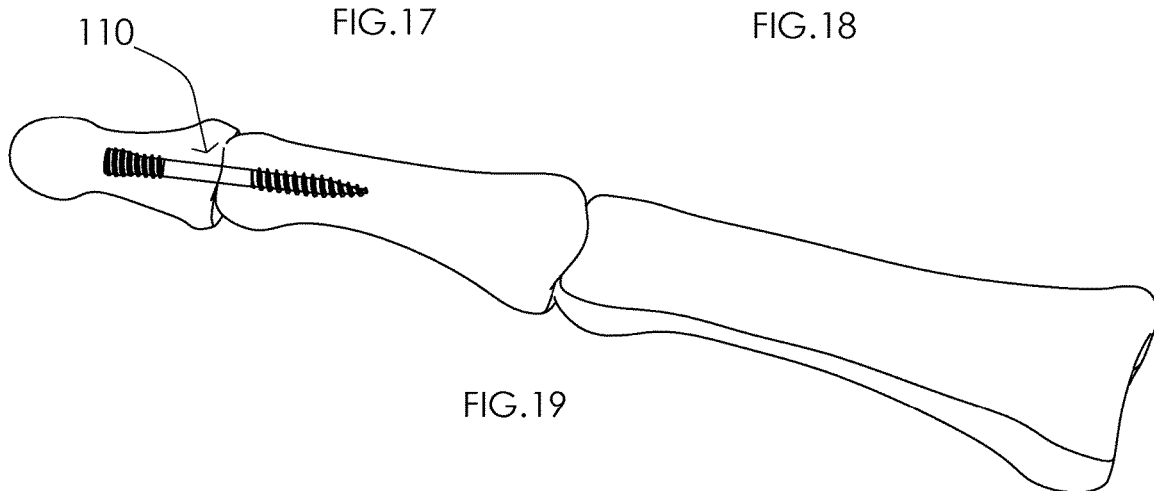
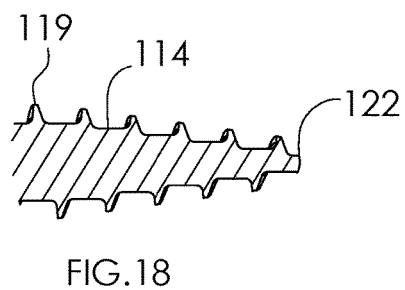
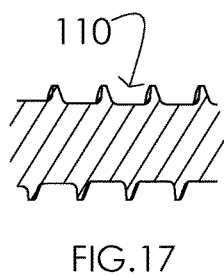
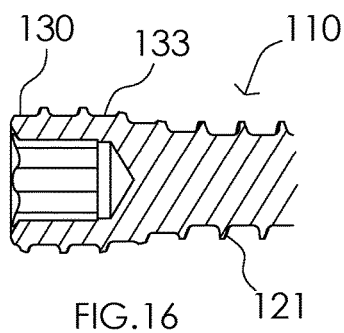
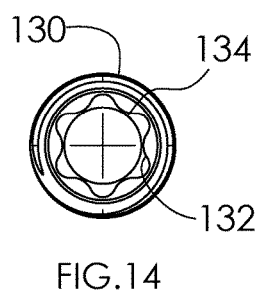
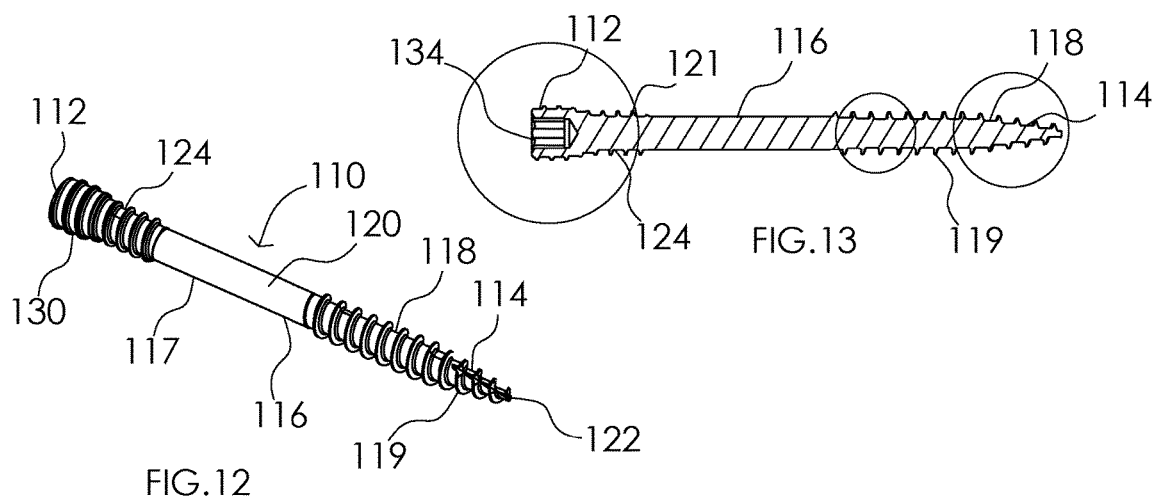
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**SMALL BONE TAPERED COMPRESSION
SCREW****FIELD OF THE INVENTION**

The present invention relates to a device and system for surgical fixation of small bones, small bone fragments, and osteotomies and more particularly to compression screw having an elongated and slowly tapered threaded leading portion which is joined to a section that is free from threads and a threaded trailing portion and more sharply tapered head which has threads that continue from the threads of the leading portion.

BACKGROUND OF THE INVENTION

Patients often suffer from late stage arthritis in phalangeal joints of the hands and feet, and this presents a variety of challenges for attending physicians. While current treatment protocols usually provide acceptable results, there is a likelihood of straight distal interphalangeal joint fusion which provides for sub-optimal outcomes. Research has shown that when a patient's distal interphalangeal joint is fused in a functional position, finger dexterity and grip strength improve over that of a patient with a straight fusion. Physicians can achieve angled fusions by using k-wire fixation, however, this immobilization protocol can fail, and lead to several complications and varied results. While the utilization of compression screws can provide reliable, strong repairs, it does not offer the additional benefit of function flexion which is provide by a properly angled and oriented implant fixation device, especially one, which provides the added benefit of compression across the joint during fusion.

Advantageous locations the use of the present invention is in the phalanges of the hand or foot. In each finger, there are three phalanges that are separated by two joints called the interphalangeal joints (IP joints). The proximal IP joint (PIP joint) is the one closest to the MCP joint. The other joint closest to the end of the finger is the distal IP joint (DIP joint). The thumb just has one IP joint. The joints are covered on the ends with articular cartilage. The foot has an analogous structure substituting the large toe for the thumb. It should be understood that there may be additional surgical techniques or locations in the body where the device of the present invention may be suitable for use.

SUMMARY OF THE INVENTION

The present invention solves the problems associated with performing a fusion technique or an osteotomy, in particular in the interphalangeal joints. The device of the invention is a compression screw having a shaft with a longitudinal axis along which there is a leading portion including a sharp spiked threaded tip, and an intermediate unthreaded portion, and a trailing threaded portion which joins the intermediate portion and the more sharply expanding or tapered head portion, which may include the same thread pitch, size and shape of the trailing shaft portion having a constant inner diameter and outer diameter. Alternatively, the trailing portion may have a lesser thread pitch compared to the tapered tip. It should be noted while that the trailing portion may be considered to be proximal to the leading portion relative to the screw itself, in use, the leading portion is intended to be implanted more proximally relative to the joint than the trailing portion. Moreover, the head portion is configured to provide for compression across the fusion joint, and to

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inhibit rotation of the compression device in the interphalangeal position as the leading portion is embedded into the intermediate phalange which is positioned at an angle with respect to the distal phalange. In addition, the present invention by provides for a percutaneous insertion in a surgical technique with an intramedullary implant designed to minimize soft tissue, cartilage and vascular damage upon insertion; and to facilitate early, active mobilization post-operative protocols for accelerated healing and earlier return to work.

The head at the trailing end includes a driving recess, such as a hexalobe, capable of being driven by a suitable driver into the opening.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view of a device in accordance with the invention;

FIG. 2 is a side cross-sectional view of the device of FIG. 1 taken along the longitudinal central axis;

FIG. 3 is an end view of the head of the device from the trailing end;

FIG. 4 is an end view of the device from the leading end;

FIG. 5 is a detail of FIG. 2 showing the threads and the head;

FIG. 6 is a detail of FIG. 2 showing the top of the threaded leading section;

FIG. 7 is a detail of FIG. 2 showing the steeply tapered spike end of the screw of FIG. 2;

FIG. 8 is a dorsal view of a skeleton of a hand showing the implant of the invention in place in a PIP fusion;

FIG. 9 is an illustration of the step of inserting a guide wire in a retrograde fashion through the distal phalange in accordance with the technique of the invention;

FIG. 10 is an illustration of the step of inserting a guide wire in a retrograde fashion through the intermediate phalange in function flexion accordance with the technique of the invention;

FIG. 11 is an illustration of the step of inserting and confirming the placement of the implant across the fusion site in accordance with the surgical technique of the invention;

FIG. 12 is an isometric view of a further embodiment of the device in accordance with the invention;

FIG. 13 is a side cross-sectional view of the device of FIG. 12 taken along the longitudinal central axis;

FIG. 14 is an end view of the head of the device of FIG. 12 from the trailing end;

FIG. 15 is an end view of the device of FIG. 12 from the leading end;

FIG. 16 is a detail of FIG. 12 showing the threads and the head;

FIG. 17 is a detail of FIG. 12 showing the far end of the threaded leading section;

FIG. 18 is a detail of FIG. 12 showing the steeply tapered spike end of the screw of FIG. 12; and

FIG. 19 is a dorsal view of a skeleton of a hand showing the implant of the invention of FIG. 12 in place in a PIP fusion.

**DETAILED DESCRIPTION OF THE
INVENTION**

FIG. 1 shows an exemplary embodiment 10 of the tapered compression screw of the present invention. The screw 10 may be formed of any suitable biocompatible material, such as surgical grade stainless steel, titanium, alloys of nickel

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and chromium, nitinol, PEEK, hydroxyapatite, bio-glass or other bio compatible materials or combinations of these materials. The screw **10** has a first end, or trailing end (i.e. relative to the screw, the proximal end), **12**, a second end, or leading end (again relative to the screw, the distal end), **14**, a shaft **16** with an outer surface **17**, and the shaft **16** including a slowly tapered spiked leading portion (i.e. a long cone) **18** which includes a thread **19** and a terminal end **22**. The leading portion **18** is joined to an intermediate portion of the shaft **20** which is free from threads and is joined to a trailing portion **24** of the shaft **16**. The trailing portion **24** has threads **21** and joins the leading portion **18** of the shaft to a compression head **30** which also includes threads **23** at the same pitch and shape as the threads **21** of the trailing portion (although in a further embodiment, the thread pitch may be changed to achieve greater compression). The head **30** also forms a cone **33** that is threaded, and which joins the threaded cylindrical portion of the trailing section of the shaft **16**. The head **30** has a driving surface **32** in a drive recess **34** formed in the top of first end **12**.

The angle of the leading tapered area is from 4° to 12°, and preferably 5-8° which is defined at the intersection of a line at the outer surface of the inner diameter of the leading area and the central axis and the compression head has an angle which is similarly determined and is from 5° to 16°, but preferably is 9-14°, and is at least 2° greater than the taper of the leading end and extends for a distance longitudinally that is 25% to 75% of the distance of the leading taper. Ideally, the leading taper extends for from 25% to 50% of the length of the screw, and the intermediate portion extends of 25% to 50% of the length and the trailing portion of the shaft extends for 15% to 50% of the length of the screw and the head extends for 5% to 15% of the length of the screw, with the screw shaft nominally comprising 1/3 trailing portion, 1/3 intermediate portion and 1/3 leading portion +/- 5-10% for each portion.

The spiked end can be driven into the intermediate phalange at an angle to create the position of functional flexion. The aggressive taper on the leading tip allows the screw to be used in facilitating angulation between two bone while still fitting into the bone, which the prior art screws do not accommodate. The driving surface **32** of the head has a hexalobe drive configuration, although any suitable driving configuration may be used. Other driving configurations that may be used include slotted, Pozidriv, Robertson, tri-wing, Torq-Set, SpannerHead, Triple Square and hex head.

The leading and trailing portions of the device includes a thread which is defined between the outer diameter and the inner diameter and can suitably include a right handed single start thread with a pitch of from 3-4, and preferably at 3+/-0.5 with a similar lead value. In the second embodiment the tip pitch is from 0.9 to 1.0 mm and preferably 0.95+/-0.02 mm, and the head pitch is from 0.70 to 0.85 mm, and preferably 0.75 mm. The trailing section and following profiles of the threads together form an angle of 25° to 75° and preferably 30° +/- 15°, and preferably +/- 10°, and with a thread depth of 0.1 mm to 0.4 mm +/- 0.02 mm, and optionally a thrust profile or a traditional bone screw buttress thread. There is a pitch differential between the threads of the conical section of the head and the spiked taper of the leading end of the screw, with the leading thread pitch being about 0.75 to 1.25, but in any case, from 1.2 to 1.5 times the pitch of the compression head, which is 0.5 to 1.0.

FIG. 8 illustrates a screw **10** in accordance with the present invention in position across a first PIP joint to secure a fusion.

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In FIG. 9, in a first step of a surgical technique in accordance with the invention, the joint is scored for fusion and a guide wire **38** is inserted in the intramedullary canal in retrograde until it abuts the inner cortical surface of the distal phalange,

In FIG. 10 the end of the finger is bent and the guide wire is inserted further into the phalanges to secure the distal phalange in a position of functional flexion relative to the intermediate phalange. A cannulated drill can be used to drill a hole across the fusion site over the guide wire.

In FIG. 11, the device **10** is driven into the opening in the phalanges by means of the drive recess. The outer diameter of the threads **28**, is slightly larger than the inner diameter of the opening in the bone. This provides bone material for threads **28** to thread into and provides a tight fit for device **10**.

FIG. 12-19 show a second embodiment **110** of the tapered compression screw of the present invention. This screw **110** has a first end, or trailing end (i.e. relative to the screw, the trailing end), **112**, a second end, or leading end (again relative to the screw, the leading end), **114**, a shaft **116** with an outer surface **117**, and the shaft **116** including a slowly tapered spiked leading portion (i.e. a long cone) **118** which includes a thread **119** and a terminal end **122**. The leading portion **118** is joined to an intermediate portion of the shaft **120** which is free from threads and is joined to a trailing portion **124** of the shaft **116**. The trailing portion **124** has threads **121** and joins the leading portion **118** of the shaft to a compression head **130** which also includes threads **123** at the same pitch and shape as the threads **121** of the trailing portion. The head **130** also forms a cone **133** that is threaded and which joins the threaded cylindrical portion of the trailing section of the shaft **116**. The head **130** has a driving surface **132** in a drive recess **134** formed in the top of first end **112**.

Having thus described some embodiments of the invention, other variations and embodiments that do not depart from the spirit of the invention will become apparent to those skilled in the art. The scope of the present invention is thus not limited to any particular embodiment, but is instead set forth in the appended claims and the legal equivalents thereof. Unless expressly stated in the written description or claims, the steps of any method recited in the claims may be performed in any order capable of yielding the desired result.

What is claimed is:

1. A surgical method for facilitating fusion between an intermediate phalange and a distal phalange comprising:
 - implanting a compression screw comprising a spiked tip along a longitudinal axis of the distal phalange;
 - placing the distal phalange at a selected angle relative to a longitudinal axis of the intermediate phalange such that the distal phalange is bent relative to the intermediate phalange, and
 - driving the spiked tip of the compression screw into the intermediate phalange at the selected angle,
 wherein the compression screw comprises a threaded first portion, an unthreaded second portion, and a threaded third portion along a longitudinal axis of the screw, the threaded first portion including a conical head and a shaft having a constant minor diameter, the unthreaded second portion including a shaft having a constant outer diameter that is the same as the minor diameter of the shaft of the threaded first portion, and the threaded third portion including the spiked tip that terminates at a conical tip.

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2. The surgical method as set forth in claim 1 wherein an angle of the conical head is greater than an angle of the conical tip.

3. The surgical method as set forth in claim 1 wherein a thread of the first portion extends along the conical head and the shaft.

4. The surgical method as set forth in claim 3 wherein the shaft of the first portion has a constant major diameter.

5. The surgical method as set forth in claim 3 wherein a thread of the third portion is continuous.

6. The surgical method as set forth in claim 3 wherein the thread along the conical head defines a conical head maximum major diameter, and the thread along the shaft of the threaded first portion defines a first portion major diameter, the conical head maximum major diameter being greater than the first portion major diameter.

7. The surgical method as set forth in claim 3 wherein the thread of the first portion is continuous.

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8. The surgical method as set forth in claim 1 wherein at least the shaft of the the first portion or the shaft of the second portion is non-cannulated.

9. The surgical method as set forth in claim 1 wherein the method is performed percutaneously.

10. The surgical method as set forth in claim 1 wherein the thread of the first portion is a buttress thread.

11. The surgical method as set forth in claim 1 wherein the conical head comprises a taper with an angle from 5° to 12°.

12. The surgical method as set forth in claim 11 wherein an angle of the conical head is greater than an angle of the conical tip.

13. The surgical method as set forth in claim 1 wherein the conical head has a first length along the longitudinal axis of the screw and the threaded third portion has a second length along the longitudinal axis of the screw, the first length being smaller than the second length.

14. The surgical method as set forth in claim 1 wherein at least the second and third portions are non-cannulated.

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